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REPORT TO THE FEDERAL HOUSING ADMINISTRATION. SEEPAGE PIT CONSTRUCTION NOTES

Thomas W. Bendixen, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

22 June 1959

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Report to
THE FEDERAL HOUSING ADMINISTRATION

SEEPAGE PIT CONSTRUCTION NOTES

June 22, 1959

PUBLIC HEALTH SERVICE...ROBERT A. TAFT SANITARY ENGINEERING CENTER

27

Report to:

THE FEDERAL HOUSING ADMINISTRATION

Notes on the Construction of Seepage Pits

by

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Details of illustrations in this document may be better studied on microfiche.

June 22, 1959

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Foreword

A study of septic tank-seepage pit systems sponsored by the Federal Housing Administration was initiated in October 1956 at the Robert A. Taft Sanitary Engineering Center. Field investigations were started in December 1956.

During the course of these studies numerous state and local health departments have been visited to review practices in the use of seepage pits. Field investigations have been conducted in seven counties in three states in which pits have been intensively studied. Some 1000 home owners have been interviewed and questioned regarding use and operation of their systems. Approximately 500 pits have been opened for observation and 200 have been studied in detail with respect to design and construction. Several hundred new pits have been observed during construction.

Design and construction varies tremendously between states and even between counties within one state. Specific practices have been developed through experience and, in many instances, for particular situations.

This report summarizes the various construction practices encountered and attempts to delineate the good features from the bad features.

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INTRODUCTION

Seepage pit is the term used to describe a general method for disposing of septic tank effluent by soil absorption. The term is sometimes confused with cesspool, but in common terminology cesspool is reserved for a pit receiving untreated sewage. In some localities a seepage pit may be known as a leaching pit or a dry well.

The seepage pit is not a universally acceptable method. Its usefulness is limited to situations where ground water pollution is not a significant factor. In some areas the use of seepage pits is prohibited by the agency having jurisdiction. The present series of studies is devoted entirely to the mechanics of introducing liquid into the soil by means of the seepage pit. Pollution is a separate subject, and this hazard should be evaluated before pits are given consideration in any locality.

Use of pits is also limited to specific soil conditions. Pits become useful in special situations where the pervious soil is very deep or where in impervious upper layer is underlaid by a porous stratum. Special as they are, these situations are common in localized areas throughout the country. Seepage pits are used extensively in the far west where the ground water table is often very deep and where deep soils with porous substrata are quite common. Obviously, pits should not be allowed to penetrate into potable ground water.

Figure 1 is a typical scene illustrating the mass application of seepage pits in the mass production of homes. The mounds of

Figure 1
Mass Application of Seepage Pits

earth in the background are spoil from the pits. Two pits approximately 40 feet deep were provided for each home in this instance. This type of standardized construction employing modern equipment is economical and popular with the building industry. If the soil is suitable, a minimum amount of time for inspection and administrative control is required on the part of the health department. Note the nearness of the houses and the small back yards. This illustrates a common fault of failing to provide sufficient room for system maintenance and space for possible later repair or additions to the system. Use of seepage pits should not be considered as justification for use of small lots.

Seepage Pit Description

A typical seepage pit is a round hole from 2 to 4 feet in diameter and 15 to 100 feet deep. The hole may or may not be lined with a porous lining or filled with gravel or stone. At a depth of one to four feet below ground surface, the hole is capped with a brick dome or a concrete slab. An inlet is provided through the sidewall of the pit or through the cap, and connected to the septic tank with a tight four-inch sewer line. An access opening may or may not be provided through the cap. Figure 2 shows a newly excavated pit before a lining is installed. In Figure 3 the pit has been lined and an inlet has been placed through one side of the pit and a dome cap is being constructed. In this system an inspection opening has been provided in the center of the dome that will be extended upward with a four-inch tile to within a few inches of the ground surface.

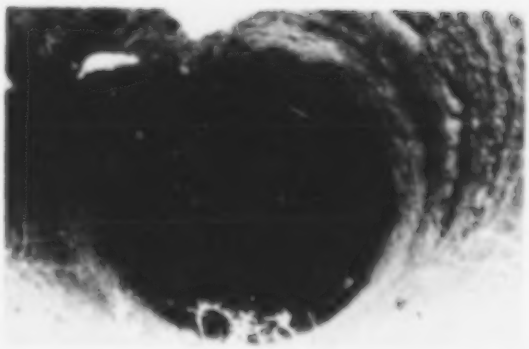


Figure 2
Newly Excavated Pit

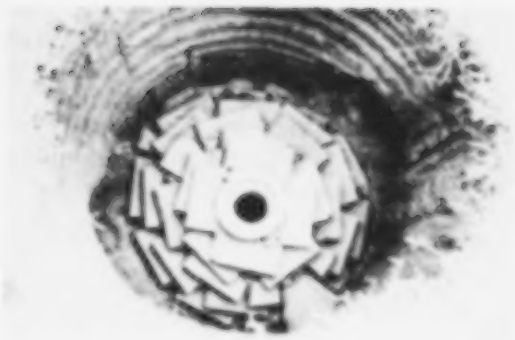


Figure 3
Brick Dome Showing Inlet and Inspection Port

CONSTRUCTION PRACTICES

Excavating Equipment

Construction practices vary from locality to locality depending on available construction material and equipment, local soil and topography, personal preferences, and local experience.

Many methods of digging seepage pits are in common use. These range from time honored hand digging to the use of specially designed augering equipment. Hand digging is resorted to only in isolated instances where topography prevents the use of conventional or special excavation equipment, or where the small number of systems being installed makes it uneconomical to use mechanical equipment. In the event of hand digging, caving protection and safety techniques such as slip linings or sheet or ring spiling must be employed.

Two types of conventional excavation equipment commonly used are backhoes, clamshells, and orange peels. Backhoes are used to dig shallow pits with a relatively large cross-sectional area. Such pits must usually be lined or filled with stone. Clamshells and orange peels are often used to dig inside of slip linings in very loose formations. As a general rule, they can only dig ten to twelve feet in depth.

By far the most common type of seepage pit excavation equipment used in the west is a powered earth auger of the type used for foundation explorations but adapted for seepage pit excavating. Figures 4 and 5 illustrate two types of this equipment. The spinner plate machine (Figure 4) brings

Figure 4
Spinner Plate Seepage Pit Auger

Figure 5
Bucket Seepage Pit Auger

the excavated soil to the surface on a flat plate. Spinning the plate throws the soil away from the excavation. The bucket type machine (Figure 5) traps the excavated material in the bucket as it is loosened. The bucket is lifted clear of the excavation and the power ring and the excavated soil is dumped away from the excavation by tripping the bottom.

The spinner plate machine is limited to digging pits to a maximum depth of about 20 feet, while the bucket type machines are capable of digging pits over 100 feet deep. The greater depth is obtained by adding extensions to the vertical shaft as excavation progresses. Many of the bucket machines have a telescoping shaft which makes it possible to drill up to about 45 feet deep without adding extensions. In the southwest, where most of the observations have been made, more seepage pits are dug with the bucket type machines than all other methods combined.

The spinner plate machine is also limited to digging a pit of the same diameter as the cutting head, which is up to about three feet. A bucket machine can excavate a pit of the same diameter as the bucket, from 18 inches to four feet, or by use of adjustable cutting tools it can also ream a bucket hole up to about six and a half feet in diameter. The common practice is to auger a pilot hole about three feet deeper than the desired seepage pit and then ream the hole to the finished diameter. The stub of the pilot hole remaining in the bottom of the pit, such as can be seen in Figure 2, is usually backfilled with the last excavated earth or with clean gravel.

Reaming tools are also used to enlarge the top of the pit to provide a ledge foundation for the pit dome as shown in Figure 6.

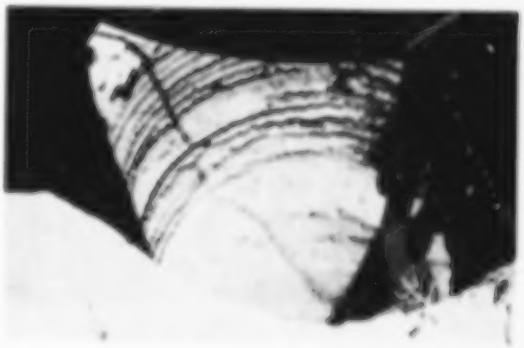


Figure 6
Foundation Ledge for Pit Dome

Lining Practices

In a few local situations, seepage pits are used without lining or support for the pit sidewalls. This type of construction occurs primarily in areas where relatively thick strata of consolidated or cemented soil materials are penetrated before a suitable porous stratum is encountered. Many such pits have been observed that are apparently standing satisfactorily, but others have caved badly. It is difficult to forecast whether or not a soil will stand without support, so consequently most pits we have observed have been lined or rock filled.

Two types of rock filled seepage pit construction have been encountered. In one type, the pit is filled to within a few feet of the ground surface with stone 4 to 6 inches in diameter. A concrete slab cover is placed directly on the stone. The effluent inlet may enter the cover or in the pit sidewall. In the second type, the pit is filled with coarse gravel to within about 10 feet of the ground surface and a porous lining used over the remaining depth.

Most of the pits observed have been lined over their full depth. Standard brick, building block, radial concrete block, redwood lumber, and precast concrete rings are lining materials most commonly used.

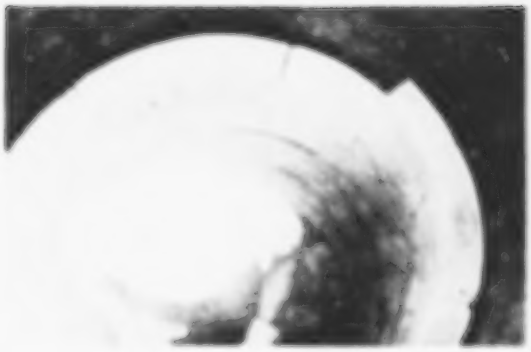
Standard brick linings are constructed by laying unmortared tiers of bricks against the raw wall of the seepage pit as shown in Figure 7.

The brick may be abutted tightly as shown or a space of a quarter to half inch left between adjacent brick. Common practice is to lay the brick flat, but some contractors lay the brick on edge which is poor practice.

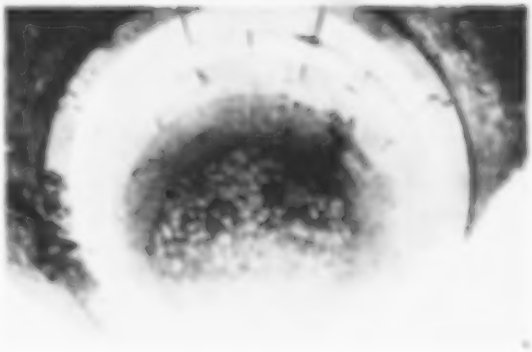
Figure 7
Brick Lining Under Construction

Several types of radial concrete block are used for seepage pit linings. The dimensions and design of these block vary according to local preference. They are generally designed to fit tightly into a specific diameter pit. Three types of block are shown in Figures 8. Those in Figure 8(a) are the most common type with ends butting flat against each other. It is assumed that the unmortared joints are sufficiently large to allow the passage of effluent. The blocks in Figure 8(b) are provided with interlocking end joints, and those in Figure 8(c) have "weep" holes to insure passage of effluent.

Two methods of installation of brick and radial block lining are used. The most common method is to lay the units up by hand. In the deeper pits, and in situations where it is dangerous for a man to work in the pit, bricking machines



(a)



(b)

(c)

Figures 8

Concrete Radial Block
for Seepage Pit Linings

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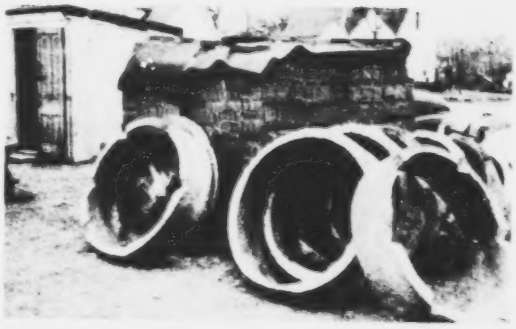
have been used. One type of bricking machine has a circular steel plate which has a series of retractable lugs around its circumference. The plate is connected by cable to a power hoist. After the first tier of block is placed on the bricking plate lugs, succeeding tiers are added as the plate is lowered into the pit. When a lining height of five or six feet is reached it is lowered to the bottom of the pit, the lugs are retracted and the plate is returned to the surface for reloading. The finished lining with a bricking machine generally does not fit the excavation quite as tightly as when it is built by hand.

Another type of lining observed is the precast concrete rings shown in Figures 9. The rings may or may not have "weep" holes. The rings are made in one, two and three foot lengths. They are particularly popular in areas where caving sands are encountered that require a caisson method of excavating. A hole slightly larger than the rings is excavated, generally with a clamshell, orange peel, or by hand, to the level of the sand. The rings are then placed in the hole and excavation continued by digging out from under the rings and allowing them to slip down. Rings are added until the desired depth of the pit is reached.

(a)



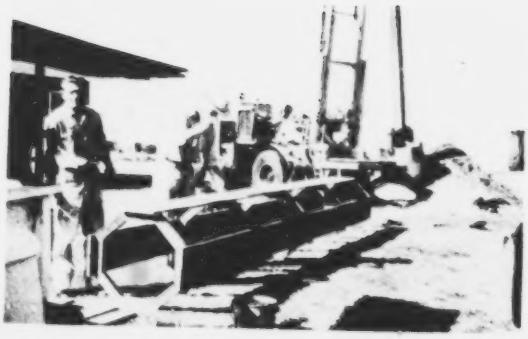
(b)

Figures 9

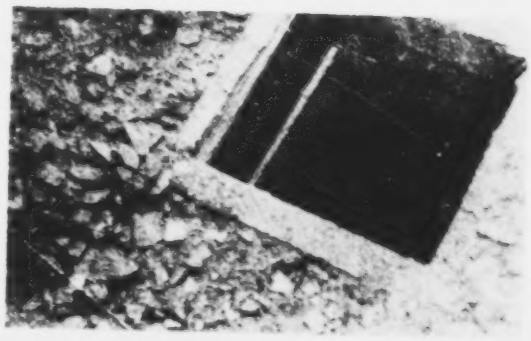
Precast Concrete Ring Lining

Another type of lining used on the west coast consists of redwood lumber boards nailed to supporting ribs to form an open-ended cylinder or box.

Figure 10(a) shows an octagonally shaped liner being fabricated. Figure 10(b) shows a box shaped liner in place. The lining sections are made up in twenty foot lengths which are stacked on top of each other to form a continuous lining in the pit. The annular space between the lining and the pit wall is generally filled with gravel as seen in Figure 10(b).



(a)

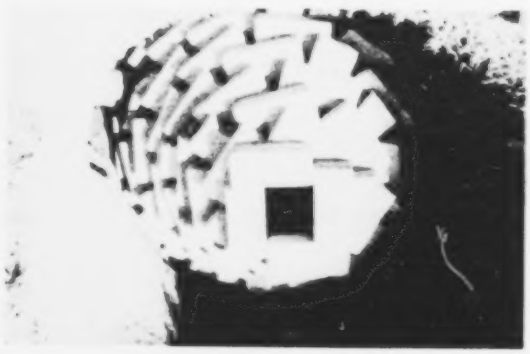


(b)

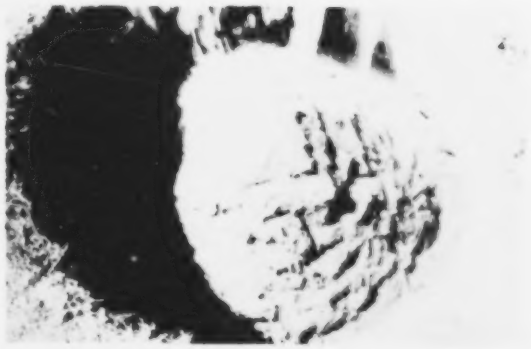
Figures 10
Redwood Lumber Lining

Domes and Lids

Basically there are two types of covers, brick domes or flat concrete lids, which are used for seepage pits. Brick domes (Figures 11) are commonly constructed by laying the brick dry and then plastering with concrete. If the pit has been lined, the top of the lining may be used as a base for the dome. In some cases the dome is built on an earth ledge which extends out a foot beyond the periphery of the excavation. An inspection opening, as in Figures 11, fitted with a removable cover is often left in the peak of the dome. The inlet is usually brought into the side of the pit just below the dome as was seen in Figure 3. Poured-in-place concrete lids are commonly used with the board lined pits. They are generally extended six to twelve inches beyond the edge of the excavation.



(a)



(b)

Figures 11
Seepage Pit Dome Cover

Connecting Lines

The connecting lines between the septic tank and the seepage pit are an important and integral part of a system. Four-inch diameter water-tight lines were used in all areas visited. Vitrified clay, concrete, asbestos cement, and bituminized fiber are usually accepted as suitable materials. Trench excavations are either made by hand or with the same equipment used for the pit. Trenches are usually too short to justify use of conventional trenching machines. A common practice in bucket auger dug systems is to drill several trench depth holes along the line of the trench as close together as possible. The soil between the holes is then caved in to form a continuous trench. While a convenient excavation technique, the method does not provide for a well bedded connection line.

When a dome cover is used, the connecting line usually enters the pit just below the dome. It may or may not have a connection to divert the flow downward. With slab covered pits the inlet may be brought in by means of a tee through the top slab in the center of the pit or through the sidewall just beneath the slab.

When multiple pits are used, general practice is to connect them in parallel through the use of a distribution box. Most repair pits are connected in series with the old pit. These connections are generally made with straight sewer outlets and inlets. A few installers preferred a tee or ell outlet connection.

Repair Practices

The most common repair practice to correct a pit failure is to add one or more pits to the system. It is such a common practice in most areas that home-owners deal directly with installers without consulting control authorities.

Pumping, blasting, acid treatment, and use of chemical and biological additives is frequently resorted to in attempting to correct seepage pit failures. Pumping is at best a temporary corrective measure. In one area ingenious home-owners had provided themselves with permanent pumping equipment so that the pit could be pumped every few weeks. The effluent was discharged to the lawn. Meager evidence indicates that blasting and acid treatment may give a modest extension of seepage pit life. Blasting, however, has been observed to cause structural damage to the pit to the extent that the systems caved badly. Acid treatment usually consists of pumping out as much of the pit contents as possible and then adding from 5 to 25 gallons of commercial sulfuric acid. No evidence was found which would indicate that biological additives have had corrective value.

CONSTRUCTION SOURCES OF MALFUNCTION

Construction plays an important part in the success or failure of a seepage pit system. Faulty practice at any stage in construction may doom an otherwise satisfactory system to a premature failure.

Soil conditions usable for seepage pit systems at any given site have been fixed by mother nature. There is no practical way, as far as is known at present, to improve the natural capacity of soil materials to absorb effluent. However, a number of construction practices have been observed that can damage or literally destroy that capacity. If seepage pits are to be successful, we must make the best use of the given soils.

Practically all of the excavating methods encountered cause some soil damage, much of which can be avoided. The primary cause of damage is smearing or compacting of the excavated surface. The damage increases

as the soil moisture content increases and as the textural size decreases. The detrimental effect of wet soils may be minimized by avoiding construction during wet periods.

Smearing damage was most frequently observed in unreamed pits. The bucket in Figure 12(a) is an example of one of the common causes of smearing damage. This bucket has worn to the point where it has become slightly conically shaped, the bottom diameter being smaller than the upper diameter. In use, the upper portion of the bucket will rub tightly against and smear the sidewalls as the pit is deepened. The type and position of the cutting blade is also conducive to soil damage when it has become dull as is the case on the bucket shown. The knife type of blade has a slicing cutting action that tends to leave a smeared and compacted soil surface. Contrast this bucket with the one in Figure 12(b). Note protective hard surface ribbing and the truer cylindrical shape; also note the sharp cutting point extending out on the lower left edge of the bucket. This tool provides a tearing cutting action that is more likely to leave a natural undamaged soil surface.

(a)

(b)

Figures 12
Type of Bucket Which May Cause Soil Damage

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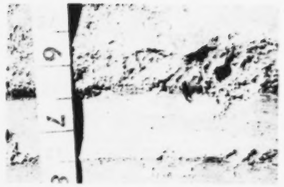
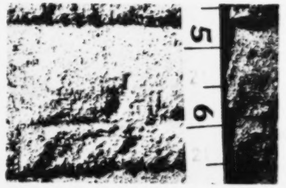
In Figure 13(a) the soil surface was cut with a blade type bucket; note the smeared surface at the bottom of the picture.

The soil surface shown in Figure 13(b) was cut with a sharp pointed tool. A much more undamaged surface is apparent.

Sidewall smearing may also be caused by excessive wobbling of the bucket in the hole. Sharp cutting teeth minimize such wobble. It has also been observed that a hole may be drilled off plumb if the rig position is allowed to move after a hole is started. Rubbing of the bucket along one wall of such a pit as the bucket is withdrawn and inserted may completely seal that wall. With reasonable care on the operator's part during drilling, and use of well-kept equipment, a vertical excavation can be maintained and a great amount of smearing damage avoided.



(a)



(b)

Figures 13
Damaged and Undamaged Soil Surfaces

Probably the best excavation technique observed, as far as preserving the natural soil properties, is the pilot hole-reaming method. Only a relatively small cutting edge is brought into contact with the soil so that a tearing action is more likely to result. The finished hole is three to twelve inches larger in diameter than the pilot hole, thus there is less chance of the bucket rubbing and smearing the finished sidewalls. Figure 6 on Page 5 illustrates the differences in surfaces obtained in the pilot hole and the reamed hole.

With the wide variety of lining methods encountered, it is natural that a wide variety of malpractice would be observed. One of the most flagrant malpractices occurs during the laying of brick or block linings. Such linings seldom fit tightly against the pit wall so that an annular space of one or two inches is left between the pit wall and lining. Many times a pit is not uniformly shaped (Figure 14) and large cavities exist behind the lining. In laying up linings in a pit such as this, workmen usually fill the spaces behind the brick with soil that has been excavated from the pit. Often the soil used for such fill is fine textured and relatively impermeable. Unfortunately, the strata of coarser and more permeable material are the ones that are most likely to cave and consequently are the ones that are most often backfilled in this manner, and thus the most often damaged. Backfill behind the lining should always be a clean coarse gravel.

Figure 14
Pit Excavation in Caving Soil

With prefabricated lumber linings, the most recent practice is to fill the annular space between the lining and pit wall with gravel. However, a large number of linings in old systems were observed that did not have gravel fill. In one survey area where linings were not gravel filled, 25 per cent of the pits inspected had lining failures. The nails holding the lining together had rusted out and the boards had collapsed. In two of the cases, the pits had subsequently caved in. Where gravel fill was used only one per cent of the pits opened had lining failure. When the pits were opened, the gravel fill was seldom found to extend to the top of the casing. This may have been due to settlement or incomplete original fill, which the field teams had no way of determining.

None of the rock-filled type pits were opened during the study since pit dimensions could not be obtained. However, judging from observation of such pits during construction, they would afford a maximum of structural stability to the pit.

Faulty construction practices were observed in the methods of providing a building base or foundation for brick and block linings. The common recommended procedure of placing a foot or two of clean sand or gravel in the bottom of the pit to form a firm foundation for the lining is seldom followed. In reamed holes, linings are many times built on an obviously unstable ledge where reaming of the pilot hole terminates. In other cases, the pilot hole is backfilled with material excavated from the pit and the lining started without any attempt to compact the fill material. Lining settlement of several inches has been observed in old pits which was undoubtedly a result of poor foundation conditions. Such settlement may lead to a variety of failures, such as

breaking and separation of inlet lines, structural failure of linings and pit covers, and even complete pit cave-ins. Standard use of a two foot fill of clean gravel in the bottom of the pit to provide a stable foundation would help to avoid much of this trouble.

Faulty foundation practices were also observed in the construction of pit covers. Generally, both the dome type and flat lid type covers were built on undisturbed earth extending at least a foot beyond the periphery of the pit proper. This provides a structurally stable cover completely separate from the pit lining. However, in some areas where brick lining was predominant, the dome was merely a continuation of the lining. In such cases the foundation faults noted previously also endanger the dome.

Materials used and construction practices followed in the installation of connecting lines have considerable influence on seepage pit dependability. Vitrified clay, concrete, asbestos cement, and bituminized fiber pipe have been observed at various sites during the studies. In one area all of 16 concrete tile connecting lines inspected were in various states of decomposition. Three of the lines were so badly decomposed that they could not be removed without their collapsing. However, in other areas concrete tile was used with apparent success. While it could not be demonstrated that the original quality of the concrete tile in the 16 systems cited was responsible for their failure, this is strongly suspected. Regardless of the cause of the concrete tile failures, it does demonstrate the need for quality control on all materials used in seepage pit systems.

Trench excavating and the bedding of connecting lines was observed to be a very haphazard operation and may have been responsible for a number of

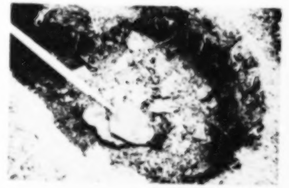
failures observed. Figure 15(a) shows a common method of excavating for connecting lines where auger equipment is used. Note the two auger holes between the distribution box, foreground, and the seepage pit dome just visible in the far pit. Holes were tunneled through two of the partitions between the pits, and the third partition was caved in. In a run of about ten feet, the connecting line was supported only at its outlet from the distribution box and where it went through the third partition wall. Even where a full trench is dug as in Figure 15(b), often no attempt is made to provide a continuous bedding or support for the connecting line. Some installations have been observed where the pipe grades were carefully set and adjusted by propping the pipe on small stones or earth mounds at each joint. Then when the trench was backfilled the pipe was knocked completely off line and grade. Breaks in the line or leaky joints result from this type of construction. A number of systems were observed where breaks in the line had occurred and effluent had flowed along the bottom of the trench to the pit, eroding the pit sidewalls to the point where the covers were undermined and the entire pit had caved in.

(a)

(b)

Figures 15
Bad Practice in Construction of Connecting Lines

A final item of dubious construction practice was observed in backfilling procedures. After a system has been completed and is awaiting inspection, or even after it is inspected and approved, it may remain open for several days before being backfilled. During this time the open excavations make convenient trash pits for the building crews for disposal of broken masonry, scrap lumber, and all sorts of waste material. Figures 16 show the conglomeration of material that was in one pit backfill. When the earth backfill is finally made, more often than not, no attention is paid to its compaction. Depressions then develop and funnel a large part of the yard surface drainage into the permeable backfill and thus into the pit. In one area where flooding irrigation was practiced, it was a common home-owner complaint that the irrigation water drained into the pit and that plumbing drainage was sluggish on irrigation days. Immediate backfilling of excavations and care in compaction would eliminate a large measure of this type of trouble.



(a)

(b)

Figures 16
Trash Fill Over a Seepage Pit

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SUGGESTED CONSTRUCTION PRACTICES

Preferred construction practices may vary from area to area depending on local soil and geology, equipment and construction materials available, and other local circumstances. The following suggestions are offered as major points to be considered to obtain good seepage pit construction.

Excavating

Soil is susceptible to damage during excavation. Digging in wet soils should be avoided as much as possible. Cutting teeth on mechanical equipment should be kept sharp. Bucket augered pits should be reamed to a larger diameter than the bucket. All loose material should be removed from the excavation.

Lining

Pits should be lined or under some circumstances filled with stone larger than two inches in diameter. If a lining is used, the pit should be first backfilled with clean gravel to a depth of one foot above the pit bottom or one foot above the reamed ledge to provide a sound foundation. Preferred lining materials are clay or concrete brick, block, or rings. Rings should have weep holes or notches to provide for seepage. Brick and block should be laid dry with staggered tight joints. Standard brick should be laid flat to form a four-inch wall. The outside diameter of the lining should be at least six inches less than the least excavation diameter. The annular space formed should be filled with coarse gravel to the top of the lining.

Pit Covers

Either brick dome or flat concrete covers are satisfactory. They should be based on undisturbed earth and extend at least 12 inches beyond

the excavation. A dome should not depend on the lining for structural support. Bricks should be either laid in cement mortar or have a two-inch covering of concrete. If flat covers are used, a prefabricated type is preferred, and they should be reinforced to be the equivalent in strength of an approved septic tank cover. A nine-inch capped opening in the pit cover is convenient for pit inspection and for making connections to repair pits.

Connecting Lines

Connecting lines should be of a sound durable material the same as used for the house to septic tank connection. Local experience with concrete tile, because of unusual soil or water characteristics, may dictate its judicious use. All connecting lines should be laid on a firm bed of undisturbed soil throughout their length. The grade of connecting line should be at least two per cent. The pit inlet pipe should extend horizontally at least one foot into the pit with a tee or ell to divert flow downward to prevent washing and eroding of the sidewalls. If multiple pits are used, or in the event repair pits are added to an existing system, they should be connected in series.

Backfilling

All excavations should be backfilled as soon as possible after completion of construction. Backfill material should be free of large stones and trash and should be well compacted and mounded a few inches higher than the natural ground surface.

CONTROL AND INSPECTION

Assuming that the major objective of the seepage pit study is realized and rational design and soil evaluation criteria are developed, and desirable construction practices are defined, then administrative control remains a major item of consideration if the best use of seepage pits is to be attained.

It has been observed repeatedly in these studies that each installer and individual workman has his own opinion on the proper design and operation of seepage pit systems. Some of the opinions are good, others are not. If individuals are left to their own devices, a variety of good and bad seepage pits result even if soils and standards are adequate. Training and instruction of persons concerned together with some system of inspection are essential.

Standardized pit construction and use of modern equipment simplifies control and inspection procedures. The fewer the types of excavating equipment, linings and types of covers permitted, the fewer are the critical points of construction that must be checked. As pointed out previously, the type and condition of excavating equipment can impair the quality of the pit. Appreciable control of this factor can be obtained by periodic inspection of equipment. If installer licensing is practiced, as in some areas, type and condition of equipment may be a requisite to renewal of the license. Control of quality of excavation through control of equipment would eliminate the need for the usual inspection during excavation. Requirement of even a brief pit log describing the soil strata would be desirable. It has been observed that a log can be checked with reasonable accuracy against observations of the excavated material at a later inspection.

Standardized construction also lends itself to simplified control which would insure use of quality materials. With a limited number of types of construction, material quality can be checked periodically at the installer's source or supply yard. One inspection of the actual system, at the time it is completed but not backfilled, to check workmanship and to assure compliance with design area and construction requirements should then be sufficient.